Wastewater Treatment Formula Sheet

1. Circumference, Area, Volume

a. Circumference	$C = 3.1416 \times \text{Diameter}$
b. Perimeter	$P = [\ 2 \times \text{Length}\ ] + [\ 2 \times \text{Width}\ ]$
c. Area	
Rectangle	$\text{Area} = \text{Length} \times \text{Width}$
Circle	$\text{Area} = 0.785 \times \text{Diameter} \times \text{Diameter}$
Triangle	$\text{Area} = \frac{1}{2} \times \text{Base} \times \text{Height}$
d. Volume	
Rectangle	$\text{Volume} = \text{Length} \times \text{Width} \times \text{Depth}$
Cylinder	$\text{Volume} = 0.785 \times \text{Diameter} \times \text{Diameter} \times \text{Depth}$
Cone	$\text{Volume} = 0.262 \times \text{Diameter} \times \text{Diameter} \times \text{Height}$
Sphere	$\text{Volume} = 0.524 \times \text{Diameter} \times \text{Diameter} \times \text{Diameter}$

2. Conversion Factors

a. ft^3 to Gallons	$\text{Volume, Gallons} = \text{Volume, } ft^3 \times 7.48 \text{ Gallons} / ft^3$
b. Gallons to Pounds	$\text{Pounds} = \text{Gallons} \times 8.34 \text{ lbs/Gallon}$
c. mg/L to Pounds	$\text{Pounds} = \text{Concentration, mg/L} \times \text{Tank Volume, MG} \times 8.34 \text{ lbs / MG / mg/L}$
d. mg/L to Pounds/Day	$\text{Pounds/Day} = \text{Concentration, mg/L} \times \text{Flow, MGD} \times 8.34 \text{ lbs / MG / mg/L}$
e. mg/L to Kilograms/Day	$\text{Kilograms/Day} = \text{Conc., mg/L} \times \text{Flow, MGD} \times 3.785 \text{ lbs / MG / mg/L}$
f. mg/KG to Pounds/Ton	$\text{Pounds/Ton} = \text{Concentration, mg/KG} \times 0.002 \text{ lbs / ton / mg/KG}$
g. Pounds to mg/L	$\text{Concentration} = \frac{\text{Quantity, lbs}}{(\text{Tank Volume, MG} \times 8.34 \text{ lbs / mg/L / MG})}$
h. Pounds/day to mg/L	$\text{Concentration} = \frac{\text{Quantity, lbs}}{(\text{Flow, MGD} \times 8.34 \text{ lbs / mg/L / MG})}$
i. Pounds/day to MGD	$\text{Flow, MGD} = \frac{\text{Quantity, lbs / day}}{(\ \text{Concentration, mg/L} \times 8.34 \text{ lbs / mg/L / MG}\ )}$

3. Flow

a. MGD to GPD	$\text{Flow, GPD} = \text{Flow, MGD} \times 1{,}000{,}000 \text{ gallons / MG}$
b. MGD to GPM	$\text{Flow, GPM} = \frac{\text{Flow, MGD} \times 1{,}000{,}000 \text{ gallons / MG}}{1{,}440 \text{ minute / Day}}$
c. MGD to CFS	$\text{Flow, cfs} = \text{Flow, MGD} \times 1.55 \text{ cfs / MGD}$

4. Chemical Weight

Using Specific Gravity	$Weight, lbs / Gallon = Specific\ Gravity \times 8.34\ lbs / Gallon$

5. Population Equivalent

$$P.E., People = \frac{BOD_5, mg/L \times Flow, MGD \times 8.34\ lbs / mg/L /MG}{0.17\ lbs\ BOD_5 / Person / Day}$$

6. Percent to Decimal Percent

$$Percent\ (Decimal) = \frac{Percent}{100}$$

7. Percent Removal

a. Based on Concentration	$\% Removal = \frac{[Influent\ Concentration - Effluent\ Concentration] \times 100}{Influent\ Concentration}$
b. Based on Quantity (lbs, lbs/day, KG or KG/day)	$\% Removal = \frac{[Influent\ Quantity - Effluent\ Quantity] \times 100}{Influent\ Quantity}$

8. Hydraulic Detention Time

a. HDT, Minutes	$HDT, Minutes = \frac{Tank\ Volume, ft^3 \times 7.48\ gal / ft^3 \times 1{,}440\ Minutes / Day}{Flow, Gallons / Day}$
b. HDT, Hours	$HDT, Hours = \frac{Tank\ Volume, ft^3 \times 7.48\ gal / ft^3 \times 24\ Hours / Day}{Flow, Gallons / Day}$
c. HDT, Days	$HDT, Days = \frac{Tank\ Volume, ft^3 \times 7.48\ gal / ft^3}{Flow, Gallons / Day}$

9. Flow Measurement

a. Flow, (Fill and Draw), GPM	$Flow\ Rate, GPM = \frac{Volume\ Added\ or\ Removed, Gallons}{Time, Minutes}$
b. Flow (Velocity), cfs	$Flow\ (Q), cfs = Channel\ Width, ft \times Water\ Depth, ft \times Velocity, fps$

10. Grit Removal

a. Velocity (float method)	$\text{Velocity, fps} = \dfrac{\text{Distance Traveled, ft}}{\text{Time Required, Seconds}}$
b. Velocity	$\text{Velocity, fps} = \dfrac{\text{Flow, MGD x 1.55 cfs / MGD}}{\text{Channels in Service x Channel Width, ft x Water Depth, ft}}$
c. Settling Time*	$\text{Settling Time, Seconds} = \dfrac{\text{Water Depth, Feet}}{\text{Settling Velocity, fps}}$
d. Required Channel Length*	$\text{Channel Length, ft} = \dfrac{\text{Water Depth, Ft x Water Velocity, fps}}{\text{Settling Velocity, fps}}$
* The settling velocity must be given or determined experimentally.	

11. Settling

a. Weir Overflow Rate	$\text{Weir Overflow Rate, GPD / ft} = \dfrac{\text{Flow, Gallon / Day}}{\text{Weir Length, ft}}$
b. Surface Loading Rate	$\text{Surface Loading Rate, GPD / ft}^2 = \dfrac{\text{Flow, Gallons / Day}}{\text{Settling Tank Area, ft}^2}$
c. Solids Loading Rate	$\text{SLR, lbs / day / ft}^2 = \dfrac{\text{Influent TSS, mg/L x Flow, MGD x 8.34 lbs / mg/L /MG}}{\text{Settling Tank Area, ft}^2}$

12. Ponds

a. Area in Acres	$\text{Area, acres} = \dfrac{\text{Area, ft}^2}{\text{43,560 ft}^2\text{ / acre}}$
b. Volume in Acre-Feet	$\text{Pond Volume, Acre Feet} = \dfrac{\text{Length, ft x Width, ft x Depth, ft}}{\text{43,560 ft}^3\text{ / Acre Foot}}$
c. Flow in Acre-Feet/Day	$\text{Flow, Acre Ffeet / Day} = \text{Flow, MGD x 3.069 Acre Feet / MG}$
d. Flow, Acre-Inches/Day	$\text{Flow, Acre Inches / Day} = \text{Flow, MGD x 36.8 Acre Inches / MG}$
e. Hydraulic Detention Time, Days	$\text{Hydraulic Detention Time, Days} = \dfrac{\text{Pond Volume, Acre Feet}}{\text{Influent Flow, Acre Feet / Day}}$
f. Hydraulic Loading	$\text{Hydraulic Loading, Inches / Day} = \dfrac{\text{Influent Flow, Acre Inches / Day}}{\text{Pond Area, Acres}}$
g. Organic Loading	$\text{O.L., lbs BOD}_5\text{ / Acre / Day} = \dfrac{\text{BOD}_5\text{, mg/L x Flow}_{in}\text{, MGD x 8.34 lbs /mg/L /MG}}{\text{Pond Area, Acres}}$
h. Population Loading	$\text{P.L., People / Acre / Day} = \dfrac{\text{Population Served by System, People}}{\text{Pond Area, Acres}}$

13. Trickling Filter

a. Total Flow (given flows)	$\text{Total Flow, MGD} = \text{Influent Flow, MGD} + \text{Recirculation Flow, MGD}$
b. Total Flow (given ratio)	$\text{Total Flow, MGD} = \text{Influent Flow, MGD} \times (1.0 + \text{Recirculation Rate})$
c. Hydraulic Loading	$\text{Hydraulic Loading, GPD} / ft^2 = \dfrac{\text{Total Flow To Filter, GPD}}{\text{Filter Area}, ft^2}$ *Total flow always includes recirculated flow.*
d. Organic Loading	$\text{O L, lbs } BOD_5 / \text{day} / 1{,}000\, ft^3 = \dfrac{BOD_5 \text{ IN, mg/L} \times Flow_{in}\text{, MGD} \times 8.34 \times 1{,}000}{\text{Filter Volume}, ft^3}$ ***Organic loading does not include recirculated flows***

14. Rotating Biological Contactors

a. Soluble BOD	$\text{SBOD, mg / L} = \text{Total } BOD_5\text{, mg/L} - (\text{'K' Factor} \times \text{Influent TSS mg/L})$
b. Total Media	$\text{Total Media / Train}, ft^2 = \sum (\text{Stage}_1, ft^2 + \text{Stage}_2, ft^2 + \ldots + \text{Stage}_n, ft^2)$ $\text{Total Media}, ft^2 = \sum (\text{Media}_{Train_1}, ft^2 + \text{Media}_{Train_2}, ft^2 + \ldots + \text{Media}_{Train_n}, ft^2)$
c. Hydraulic Loading	$\text{Hydraulic Loading, GPD} / ft^2 = \dfrac{\text{Influent Flow MGD} \times 1{,}000{,}000 \text{ gal / MG}}{\text{Total Media Area}, ft^2}$
d. Soluble Organic Loading	$\text{SOL, lbs} / 1{,}000\, ft^2 / \text{Day} = \dfrac{SBOD_{in}\text{, mg/L} \times \text{Flow, MGD} \times 8.34 \times 1{,}000}{\text{Total Media Area}, ft^2}$
e. Total Organic Loading	$\text{TOL, lbs} / 1{,}000\, ft^2 / \text{Day} = \dfrac{\text{Total } BOD_{in}\text{, mg/L} \times \text{Flow, MGD} \times 8.34 \times 1{,}000}{\text{Total Media Area}, ft^2}$

15. Activated Sludge

a. Settled Sludge Volume	$\text{SSV, mL/L} = \dfrac{\text{Settled Sludge Volume (SSV), mL} \times 1{,}000 \text{ mL/L}}{\text{Sample Volume, mL}}$
b. Settled Sludge Volume	$\%\, SSV = \dfrac{\text{Settled Sludge Volume (SSV), mL} \times 100}{\text{Sample Volume, mL}}$
c. Return Rate (By SSV)	$\text{Return, MGD} = \dfrac{SSV_{30}}{1000 \;\; SSV_{30}} \times Flow_{in}\text{, MGD}$
d. Return Rate (By SVI)	$\text{RASSS, mg/L} = \dfrac{1{,}000{,}000}{SVI}$ $\%\ \text{Return} = \dfrac{Flow_{in} \times \text{MLSS, mg/L}}{\text{RASSS, mg/L} \;\; \text{MLSS, mg/L}}$
e. Return Rate (Clarifier Mass Balance)	$\dfrac{[\text{MLSS, mg/L} \times (Flow_{in}\text{, MGD} + \text{RAS Flow, MGD})] + (\text{WAS Flow, MGD} \times \text{WASSS, mg/L})}{\text{RASSS, mg/L} + \text{MLSS, mg/L}}$

15. Activated Sludge (continued)

f. Clarifier Solids (Core Sample)	$Solids_C, lbs = Core\ Sample\ TSS, mg/L \times Volume_C\ MG \times 8.34\ lbs/mg/L/MG$
g. Clarifier Solids (MLSS)	$Solids_C = MLSS, mg/L \times Volume_C, MG \times 8.34\ lbs/mg/L/MG$
h. Clarifier Solids (MLSS and RASSS)	$Solids_C, lbs = \left(\frac{MLSS, mg/L + RASSS, mg/L}{2}\right) \times Volume_C, MG \times 8.34\ lbs/mg/L/MG$ C = Clarifier or Settling Tank MLSS = Mixed Liquor Suspended Solids in milligrams / Liter RASSS = Return Activated Sludge Suspended Solids in milligrams / Liter
i. Sludge Volume Index	$SVI = \frac{Settled\ Sludge\ Volume, (SSV)_{30\ minutes} \times 1{,}000}{MLSS, mg/L}$
j. F:M Ratio	$\frac{Aeration\ Influent\ COD\ or\ BOD_5, mg/L \times Aeration\ Influent\ Flow, MGD \times 8.34}{MLVSS, mg/L \times Aeration\ Volume, MG \times 8.34}$
k. Desired MLVSS, (lbs)	$MLVSS, lbs = \frac{Primary\ Effluent\ BOD_5\ or\ COD, mg/L \times Flow, MGD \times 8.34}{Desired\ F:M\ Ratio}$
l. Desired MLVSS (mg/L)	$MLVSS, mg/L = \frac{Desired\ MLVSS, lbs}{(Aeration\ Volume, MG \times 8.34)}$
m. Waste Volatile Solids (Based on F:M)	Waste, lbs = Actual MLVSS, lbs - Required MLVSS, lbs
n. Waste Rate, MGD (Based on F:M)	$Waste, MGD = \frac{Waste\ Volatile\ Solids, lbs/day}{(Waste\ Volatile\ Concentration, mg/L \times 8.34)}$
o. MCRT, Days	$\frac{[MLSS, mg/L \times (Aeration, MG + Settling, MG) \times 8.34]}{(WASSS, mg/L \times WAS, MGD \times 8.34) + (TSS_{out}, mg/L \times Flow_{out}, MGD \times 8.34)}$
p. Waste Solids, lbs/day (Based on MCRT)	$\left[\frac{(MLSS, mg/L \times (Aeration\ Vol., MG + Settling\ Vol., MG) \times 8.34)}{Desired\ MCRT, days}\right] - (TSS_{out}, mg/L \times Flow_{out}, MGD \times 8.34)$
q. Waste Rate, MGD (Based on MCRT)	$Waste, MGD = \frac{Waste\ Solids, lbs/day}{Waste\ Activated\ Sludge\ Concentration, mg/L \times 8.34}$
r. Waste Rate, GPM	$Waste\ Rate, gpm = \frac{Waste\ Rate, MGD \times 1{,}000{,}000\ gal/MG}{1{,}440\ minutes/day}$

16. Chemical Addition

a. Demand	$Demand, mg/L = Dose, mg/L - Residual, mg/L$
b. Dose, mg/L	$Dose, mg/L = \frac{Feed\ Rate, lbs/day}{Daily\ Flow, MGD \times 8.34\ lbs/mg/L/MG}$
c. Required Chemical (Feed Rate, lbs/day)	$Required\ Chemical_{industrial}, lbs/Day = \frac{Dose, mg/L \times Daily\ Flow, MGD \times 8.34\ lbs/mg/L/MG}{\%(decimal)\ Active\ Ingredient\ in\ Industrial\ Chemical}$

16. Chemical Addition (Continued)

d. Feed Rate, gpd	$\text{Feed, gpd} = \dfrac{\text{Required Chemical}_{\text{Industrial}}\text{, lbs/day}}{\text{Weight / Gallon of Chemical}_{\text{Industrial}}\text{, lbs / gal}}$
e. Feed Rate, gpm	$\text{Feed, gpm} = \dfrac{\text{Required Chemical}_{\text{Industrial}}\text{, lbs/day}}{\text{Weight / Gallon of Chemical}_{\text{Industrial}}\text{, lbs / gal x 1,440 minutes / day}}$
f. Feed Rate, mL/minute	$\text{Feed, mL / minute} = \dfrac{\text{Required Chemical}_{\text{industrial}}\text{, lbs / day x 3,785 mL / gal}}{\text{Weight / Gallon of Chemical}_{\text{Industrial}}\text{, lbs / gal x 1,440 min / day}}$
g. Supply Required	$\text{Required Supply, containers} = \dfrac{\text{Feed Rate, lbs / day x Days Supply Required, days}}{\text{Weight of Chemical in a Full Container, lbs / container}}$
h. Supply on Hand	$\text{Supply on Hand, days} = \dfrac{\text{\# Full Containers x Weight of Chemical in a Full Container, lbs / container}}{\text{Chemical Feed Rate, lbs / day}}$
i. Increases, (price, usage, or for safety)	Increase = Current Amount x [1.0 + % (decimal) Increase]
j. Chemical Cost	
k. Chemical Makeup (dry chemical)	$\text{Required, lbs} = \dfrac{\text{\%Active Chemical}_{\text{working}}\text{ x Volume, gallons x 8.34 lbs / gallon}}{\text{\%Active Chemical}_{\text{supply}}}$
l. Chemical Makeup (solution)	$\text{Volume}_{\text{Makeup}} = \dfrac{\text{Concentration}_{\text{Working}}\text{ x Volume}_{\text{Working}}}{\text{Concentration}_{\text{Makeup}}}$
m. Active Ingredient	$\text{Chemical Used}_{\text{Active Ingredient}} = \text{Chemical Used, lbs x \% Active Ingredient}$

17. Solids Pumping

a. Estimated Pump Rate (gallons/minute)	$\text{Rate, gpm} = \dfrac{(\text{TSS}_{in} - \text{TSS}_{out})\text{ x Flow, MGD}}{\text{\% Solids x Pump Time, minutes / day}}$
b. Gallon pumped GPD	GPD = Pump Rate, gpm x Cycles, Cycles / day x Cycle Time, minutes / cycle
c. Solids Pumped lbs/day	Solids, lbs / day = Solids Volume, gpd x 8.34 lbs / gal ´ % (decimal) Solids
d. Volatile Solids Pumped, lbs/day	Volatile Solids, lbs / day = Solids Volume, gpd x 8.34 lbs / gal x % Solids x % Volatile Matter All % values must be in decimal form.

18. Thickening

a. Solids Loading Rate (SLR) lbs/day/ft^2	$\text{SLR, lbs / day / ft}^2 = \dfrac{\text{TSS}_{in}\text{, mg / L x Flow}_{in}\text{, MGD x 8.34 lbs / gallon}}{\text{Thickener Area, ft}^2}$
b. Solids Loading Rate (SLR) lbs/hour/ft^2	$\text{Solids Loading, lbs / hr / ft}^2 = \dfrac{\text{Solids Applied, lbs / hour}}{\text{Thickener Area, ft}^2}$

18. Thickening (continued)

c. Solids Volume Ratio (SVR)	$SVR = \frac{\text{Solids Blanket Volume, gallons}}{\text{Thickener Influent Flow, gallons / day}}$
d. Hydraulic Loading	$\text{Hydraulic Loading, gpd / } ft^2 = \frac{\text{Total Thickener Influent Flow, gpd}}{\text{Thickener Area, } ft^2}$
e. Air : Solids Ratio	$\text{Air : Solids Ratio} = \frac{\text{Air Flow Rate, } ft^3 \text{ / minute x 0.075lbs / } ft^3}{\text{Sludge Flow, gpm x \% Solids x 8.34 lbs / gallon}}$
f. Concentration Factor	$\text{Concentration Factor} = \frac{\text{\% Solids Thickener Sludge}_{out}}{\text{\% Solids Thickener Sludge}_{in}}$

19. Aerobic Digestion

a. Volatile Solids Loading lbs/day/ft^3	$\text{Volatile Solids Loading, lbs /day / } ft^3 = \frac{\text{Volatile Solids Added, lbs / day}}{\text{Digester Volume, } ft^3}$
b. Digestion Time (based on flow)	$\text{Digestion Time, days} = \frac{\text{Digester Volume, gallons}}{\text{Influent Flow, gpd}}$
c. Digestion Time (based on solids)	$\text{Digestion Time, days} = \frac{\text{Digester Solids, pounds}}{\text{Influent Solids, lbs / day}}$
d. Chemical Requirement	$\text{Chemical Req'd} = \frac{\text{Chemical Used}_{lab}\text{, mg x Digester Volume, MG x 8.34 lbs / mg / L /MG}}{\text{Sludge Volume}_{lab}\text{, Liters}}$
e. Volatile Matter Reduction	$\text{\% V. M. Reduction} = \frac{(\text{\% V.M}_{.in} - \text{\% V.M}_{.out}) \times 100}{[\text{\% V.M}_{.in} - (\text{\% V.M}_{.in} \times \text{\% V.M}_{.out})]}$

20. Anaerobic Digestion

a. Seed Volume	$\text{Seed, gallons} = \text{Digester Volume, gallons x Desired \% Seed Volume}$
b. Volatile Solids Loading	$\text{Volatile Solids Loading, lbs /day / } ft^3 = \frac{\text{Volatile Solids Added, lbs / day}}{\text{Digester Volume, } ft^3}$
c. Volatile Acids/ Alkalinity Ratio	$\text{V. A. : Alkalinity Ratio} = \frac{\text{Volatile Acids, mg / L}}{\text{Alkalinity, mg / L}}$
d. Chemical Requirement	$\text{Chemical Req'd} = \frac{\text{Chemical Used}_{lab}\text{, mg x Digester Volume, MG x 8.34 lbs / mg / L /MG}}{\text{Sludge Volume}_{lab}\text{, Liters}}$
e. Volatile Matter Reduction	$\text{\% V. M. Reduction} = \frac{(\text{\% V.M}_{.in} - \text{\% V.M}_{.out}) \times 100}{[\text{\% V.M}_{.in} - (\text{\% V.M}_{.in} \times \text{\% V.M}_{.out})]}$
f. Gas Production ft^3/Day	$\text{Gas, } ft^3 = \text{Volatile Solids}_{in}\text{, lbs / day x \% V. M. Reduction x Rate, } ft^3 \text{ / lb V.M. Destroyed}$

1. Biosolids Disposal

a. Solids Production (dry tons/year)	$Solids, dt / year = \frac{Solids\ Produced,\ lbs / MG \times Average\ Daily\ Flow,\ MGD \times 365\ days / year}{2{,}000\ pounds / ton}$
b. Solids Production (wet tons/year)	$Solids, wt / year = \frac{Solids\ Produced,\ lbs / MG \times Average\ Daily\ Flow,\ MGD \times 365\ days / year}{\%\ (decimal)\ Solids \times 2{,}000\ pounds / ton}$
c. Plant Available Nitrogen (PAN) (lbs/dry ton)	$[(Organic - N,\ mg/kg \times f_1) + (Ammonia - N,\ mg/kg \times V_1)] \times 0.002$ f_1 = Mineralization Rate (assume 0.20) V_1 = Volatilization Rate Injected Sludge = 1.0 Incorporated Within 24 hrs = 0.85 Incorporated within 7 days = 0.70
d. Application Rate (nitrogen basis)	$Application\ Rate,\ Dry\ Tons / Acre = \frac{Plant\ Required\ Nitrogen,\ lbs / acre}{Plant\ Available\ Nitrogen,\ lbs / dry\ ton}$
e. Metals Loading lbs/acre	$Loading,\ lbs / Acre = Concentration,\ mg/kg \times Application\ Rate,\ D.T./acre \times 0.002\ mg/kg/dry\ ton$
f. Allowable Applications (Metals Basis)	$Maximum\ Applications = \frac{Maximum\ Allowable\ Metals\ Loading,\ lbs / acre}{Metal\ Loading / Application,\ lbs / acre / application}$
g. Site Life (metal basis)	$Site\ Life = \frac{Allowable\ Applications}{Frequency,\ applications / year}$

22. Pumping

a. Head to Pressure	$Pressure,\ psi = Head,\ ft \times 0.433\ psi/ft$
b. Pressure to Head	$Head,\ ft = Pressure,\ psi \times 2.31\ ft/psi$
c. Work	$Work,\ ft-lbs = Weight,\ lbs \times Height,\ ft$
d. Power	$Power,\ ft-lbs/minute = \frac{Work,\ ft-lbs}{Time,\ minutes}$
e. Static Head, ft	$Static\ Head,\ ft = Discharge\ Tank\ Elevation,\ ft - Supply\ Tank\ Elevation,\ ft$
f. Total Dynamic Head	$TDH,\ ft. = Static\ Head,\ ft. + Friction\ Head,\ ft. + Velocity\ Head,\ ft.$ TDH = Total Dynamic Head
g. Horsepower	$Horsepower = \frac{Power,\ ft-lbs/min}{33{,}000\ ft-lbs/minute/HP}$
h. Water Horsepower	$Water\ Horsepower,\ whp = \frac{Pump\ Rate,\ gpm \times Total\ Head,\ ft \times 8.34\ lbs/gal.}{33{,}000\ ft\ lbs / minute / hp}$
i. Brake Horsepower	$Brake\ Horsepower,\ bhp = \frac{Water\ Horsepower,\ HP}{\%\ Efficiency_{pump}}$
j. Motor Horsepower	$Motor\ Horsepower,\ mhp = \frac{Brake\ Horsepower,\ HP}{\%\ Efficiency_{motor}}$

k. Centrifugal Pump Affinity Law	
Capacity	$\text{Flow}_2\text{, cfs} = \frac{\text{Pump Speed}_2}{\text{Pump Speed}_1} \times \text{Flow}_1\text{, cfs}$
Head	$\text{Head}_2 = \left(\frac{\text{Pump Speed}_2}{\text{Pump Speed}_1}\right)^2 \times \text{Head}_1$
Brake Horsepower	$\text{Bhp}_2 = \left(\frac{\text{Pump Speed}_2}{\text{Pump Speed}_1}\right)^3 \times \text{Bhp}_1$

23. Electrical Energy

a. Hp to kilowatts (kW)	*Kilowatts = Horsepower x 0.746 Kw / hp*
b. kW to kilowatt hrs	*Kilowatt Hour = Kilowatts Used x Hours Operated*
c. Power Cost	*Cost = Kilowatt hours used x Cost / Kilowatt*

24. Sampling

a. Composite Sample Volume, mL	$\text{Sample Volume}_T = \frac{\text{Plant Flow}_T\text{, MGD x Total Sample Required, mL}}{\text{\# Samples To Be Collected x Average Daily Flow, MGD}}$ *T = Sample Collection Time*
b. Proportioning Factor (PF)	$\text{Proportioning Factor} = \frac{\text{Total Sample Required, mL}}{\text{\# of Samples Collected x Average Daily Flow, MGD}}$
c. Sample Volume (Using PF)	$\text{Sample Volume, mL} = \text{Flow}_T \text{ x PF}$ *T = Time sample is collected.*

25. Alkalinity

a. Conventional	$\text{Alkalinity as CaCO}_3\text{, mg/L} = \frac{\text{A x N x 50,000}}{\text{Sample Volume, mL}}$ *A = Volume of Standard Acid Used* *N = Normality of Standard Acid*
b. Low Level	$\text{Alkalinity as CaCO}_3\text{, mg/L} = \frac{\text{(2B - C) x N x 50,000}}{\text{Sample Volume, mL}}$ *B = Volume of Standard Acid Used to reach pH 4.3 - 4.5* *C = Total volume of Standard Acid for titration* *N = Normality of Standard Acid*

26. Hardness

a. EDTA Standardization	$EDTA,\ CaCO_3\ Equivalence\ (B) = \dfrac{Volume\ of\ CaCO_3\ Solution\ Titrated,\ mL}{EDTA\ Titrant\ Used,\ mL}$
b. Hardness, mg/L Calcium Carbonate	$\text{Hardness (EDTA) as } CaCO_3 = \dfrac{A \times B \times 1{,}000}{\text{Sample Volume, mL}}$ A = EDTA Used in Titration, mL B = EDTA $CaCO_3$ Equivalence, mL / mL

27. Ammonia Nitrogen

a. Nesslerization	$NH_3\ N,\ mg/L = \dfrac{A}{Sample\ Volume,\ mL} \times \dfrac{B}{C}$ *A = Micrograms of N from calibration curve* *B = Volume of distillate collected* *C = Volume of distillate used for nesslerization* *Sample Volume = Original sample volume placed in distillation flask*
b. Titration	$NH_3 - N,\ mg/L = \dfrac{(A - B) \times 280}{Sample\ Volume,\ mL}$ *A = Volume of titrant used for sample* *B = Volume of titrant used for blank* *Sample Volume = Volume of sample used for titration*

28. Biochemical Oxygen Demand

a. Unseeded Samples	$BOD_5,\ mg/L = \dfrac{(D.O._{Start},\ mg/L - D.O._{Final},\ mg/L) \times 300\ mL}{Sample\ Volume,\ mL}$
b. Seed Correction Factor	$Seed\ Correction,\ mg/L = \dfrac{BOD_{seed}}{300\ mL} \times mL\ Seed\ in\ the\ Sample\ Dilution$
c. Seeded Samples	$BOD_5,\ mg/L = \dfrac{[(D.O._{Start},\ mg/L - D.O._{Final},\ mg/L) - Seed\ Correction] \times 300\ mL}{Sample\ Volume,\ mL}$

29. Chemical Oxygen Demand

a. FAS Standardization (Open Reflux)	$FAS,\ Molarity = \dfrac{Volume\ of\ 0.0417M\ K_2Cr_2O_7,\ mL \times 0.25}{FAS\ Titrant\ Added,\ mL}$
b. FAS Standardization (Closed Reflux)	$FAS,\ Molarity = \dfrac{Volume\ 0.0167\ M\ K_2Cr_2O_7,\ mL \times 0.10}{FAS\ Titrant\ Added,\ mL}$
c. COD	$COD\ as\ mg\ O_2/L = \dfrac{(A - B) \times C \times 8000}{Sample\ Volume,\ mL}$ *A = FAS Used For Blank, mL* *B = FAS Used For Sample, mL* *C = FAS Molarity*

30. Total Residual Chlorine

a. Iodometric Direct Titration	$TRC, mg/L = \frac{(Titrant, mL - Blank, mL) \times Titrant\ Normality, N \times 35{,}450}{Sample, mL}$
b. Iodometric Back Titration (No Iodine correction)	$TRC, mg/L = \frac{PAO\ Added,\ mL\ (5 \times Iodine\ Used,\ mL) \times 200}{Sample\ Volume,\ mL}$
c. Iodine Correction	$Iodine\ Correction\ Factor = \frac{Iodine\ Normality_{actual}}{0.0282\ N}$
d. Iodometric Back Titration (With Iodine correction)	$TRC, mg/L = \frac{PAO\ Added,\ mL\ (5 \times Iodine\ Used,\ mL \times CF) \times 200}{Sample\ Volume,\ mL}$
e. Iodometric Back Titration Iodate Titrant	$TRC, mg/L = \frac{(Iodate\ Used_{blank} - Iodate\ Used_{sample}) \times 200}{Sample\ Volume, mL}$

31. Dissolved Oxygen

a. Winkler Titration	$D.O., mg/L = \frac{Titrant,\ mL \times Normality \times 8{,}000}{Equivalent\ Sample\ Volume,\ mL}$ If N = 0.0250 & Sample Volume = 200 mL then : Titrant Used = D.O. , mg / L

32. Fecal Coliform

a. Multiple Tube	$MPN / 100\ mL = MPN_{chart} \times \frac{Sample\ Volume\ In\ First\ Dilution_{chart}}{Sample\ Volume\ in\ First\ Dilution_{sample}}$
b. Membrane Filtration	$Colonies / 100\ mL = \frac{Colonies\ Counted}{Sample\ Volume, mL} \times 100\ mL$

33. Nitrate Nitrogen

a. Brucine Sulfate	$NO_3 - N, mg/L = \frac{NO_3 - N\ Concentration,\ micrograms}{Sample\ Volume\ In\ Reaction\ Tube,\ mL}$
b. Cadmium Reduction	$NO_3 - N, mg/L = Nitrate/Nitrite, mg/L - Nitrite, mg/L$

34. Nitrite Nitrogen

a. Diazotization Diluted sample	$NO_2 - N = C \times \frac{V}{S}$ C = NO_2 - N Concentration, mg / L V = Total volume after dilution, mL S = Sample volume in dilution, mL

35. Phosphorus

a. Phosphorus	$$\text{Phosphorus, mg P / L} = \frac{\text{Phosphorus From Standard Curve, mg} \times 1{,}000}{\text{Sample Volume, mL}}$$

36. Total Suspended Solids

a. TSS, mg/L	$$\text{Total Suspended Solids, mg / L} = \frac{(A - B) \times 1{,}000 \text{ mg / gram} \times 1{,}000 \text{ mL / L}}{\text{Sample Volume, milliliters}}$$ A = Weight of Dried Solids, Filter & planchet or dish in grams B = Tare Weight (Dried Filter & planchet or dish) in grams

37. Total Kjeldahl Nitrogen

a. Nesslerization	$$\text{TKN - N, mg / L} = \frac{A}{\text{Sample Volume, mL}} \times \frac{B}{C}$$ A = Micrograms of N from calibration curve B = Volume of distillate collected C = Volume of distillate used for nesslerization Sample Volume = Original sample volume placed in distillation flask
b. Titration	$$\text{TKN - N, mg / L} = \frac{(A - B) \times 280}{\text{Sample Volume, mL}}$$ A = Volume of titrant used for sample B = Volume of titrant used for blank Sample Volume = Volume of sample used for titration

38. Total Volatile Suspended Solids

a. TVSS, mg/L	$$\text{Volatile Solids, mg / L} = \frac{(A - C) \times 1{,}000 \text{ mg / gram} \times 1{,}000 \text{ mL / L}}{\text{Sample Volume, milliliters}}$$ A = Weight of Dried Solids & Support C = Weight of Ash & Support

39. Residual (Sludge) Solids Tests

a. % Solids	$$\text{\% Solids} = \frac{\text{Dry Solids, grams}}{\text{Residual (Solids \& Water), grams}} \times 100$$
b. % Volatile Matter	$$\text{\% Volatile Matter} = \frac{\text{(Dry Solids, grams - Ash, grams)}}{\text{Dry Solids, grams}} \times 100$$
c. % Moisture	$$\text{\% Moisture} = \frac{\text{Residual (Solids \& Water), grams - Dry Solids, grams)}}{\text{Residual (Solids \& Water), grams}} \times 100$$ or $$\text{\% Moisture} = 100 - \text{\% Solids}$$

40. VPDES Reporting

a. Average Monthly Concentration	$AMC, mg/L = \frac{\sum(Test_1 + Test_2 + Test_3 + ... + Test_n)}{N(\text{Tests during month})}$
b. Average Weekly Concentration	$AWC, mg/L = \frac{\sum(Test_1 + Test_2 + Test_3 + ... + Test_n)}{N(\text{tests during calendar week})}$
c. Average Daily Concentration	$ADC, mg/L = \frac{\sum(Test_1 + Test_2 + Test_3 + ... + Test_n)}{N(\text{Tests during day})}$
d. Average Hourly Concentration	$AHC, mg/L = \frac{\sum(Test_1 + Test_2 + Test_3 + ... + Test_n)}{N(\text{tests during 60 minute period})}$
e. Daily Quantity	*DailyQuantity, KG / Day = Conc. , mg / L x Flow, MGD x 3.785 lbs/MG/mg/L* *Conc. = Individual Test Result in mg / L* *Flow = Flow on day sample was collected in MGD.*
f. Average Monthly Quantity	$AMQ, KG/day = \frac{\sum(DQ_1 + DQ_2 + DQ_3 + ... + DQ_n)}{N(\text{Tests during month})}$
g. Average Weekly *Quantity	$AWQ, KG/day = \frac{\sum(DQ_1 + DQ_2 + DQ_3 + ... + DQ_n)}{N(\text{tests during calendar week})}$
h. Geometric Mean (Xy)	$\text{Geometric Mean} = \sqrt[n]{Test_1 \times Test_2 \times Test_3 \times \ldots \times Test_n}$
i. Geometric Mean (log)	$\text{Geometric Mean} = \text{Antilog}\left[\frac{(\log X_1 + \log X_2 + \log X_3 + \ldots + \log X_n)}{N, \text{Number of Tests}}\right]$

41. Nutrient General Permit Reporting

a. Daily Loading, lbs/day	$\text{Daily Loading, lbs/day} = \text{Concentration, mg/L} \times \text{Flow, MGD} \times 8.3438$
b. Average Monthly Load	$\text{Average Monthly Load} = \frac{\sum \text{Daily Loading, lbs/day}}{\text{Number of Days samples were collected}}$
c. Monthly Load	$\text{Monthly Load} = \text{Average Monthly Load} \times \text{Number of Days in Month}$
d. Annual Load, Year to Date	$\text{Annual Load, Year to Date} = \sum \text{MonthlyLoad}_{January} + \ldots + \text{Monthly Load}_{current\ month}$
e. Annual Load	$\text{Annual Load, lbs} = \sum \text{Monthly Load}_{Jan} + \ldots + \text{Monthly Load}_{Dec}$
f. Monthly Concentration	$\text{Monthly Concentration} = \frac{\sum \text{Daily Concentration}}{\text{Number of days samples were collected}}$
g. Average Annual Concentration Year to Date	$\text{Annual Concentration, YTD} = \frac{\sum \text{Average Conc.}_{January} + \ldots + \text{Average Conc.}_{Current\ Month}}{\text{Number of Months}}$
h. Average Annual Concentration	$\text{Annual Concentration} = \frac{\sum \text{Average Conc.}_{January} + \ldots + \text{Average Conc.}_{December}}{12}$

42. Conversion Factor Table

To Change From:	*To:*	*Multiply by:*
Feet (ft)	*Inches (in)*	*12*
Yards (yd)	*Feet (ft)*	*3*
Yards (yd)	*Inches (in)*	*36*
Miles (mi)	*Yards (yd)*	*1,760*
Miles (mi)	*Feet (ft)*	*5,280*
Cubic Feet (ft^3)	*Gallons (gal)*	*7.48*
Cubic Feet (ft^3)	*Pounds-Wastewater (lbs)*	*62.4*
Cubic Feet (ft^3)	*Pounds-Air (lbs)*	*0.075*
Gallons (gal)	*Pounds (lbs)*	*8.34*
Gallons (gal)	*Liters (L)*	*3.785*
Gallons	*Kilograms*	*3.785*
Million Gallons/Day (MGD)	*Gallons/Day (gpd)*	*1,000,000*
Million Gallons/Day (MGD)	*Gallons/Minute (gpm)*	*694*
Million Gallons/Day (MGD)	*Cubic Feet/Second (cfs)*	*1.55*
Million Gallons/Day (MGD)	*Acre-feet/day*	*3.069*
Liters/Second (L/s)	*Gallons/Minute (gpm)*	*15.85*
Million Gallons/Day (MGD)	*Liters/second*	*43.8*
Gallons/day	*Cubic Meters/Day*	*0.003785*
Acres (Ac)	*Square Feet (ft^2)*	*43,560*
Acre Feet (Ac-ft)	*Gallons (gal)*	*325,829*
Acre Inches (Ac-in)	*Gallons (gal)*	*27,152*
Liters (L)	*Milliliters (mL)*	*1,000*
Kilograms (Kg)	*Pounds (lbs)*	*2.2*
Meters (m)	*Feet (ft)*	*3.3*
Cubic Meters (m^3)	*Gallons (gal)*	*269*
Pounds (lbs)	*Grams (g)*	*454*
Ton (t)	*Pounds (lbs)*	*2,000*